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by

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Abstract

By using the case of the high-speed railway scheduled to open in 2027 in Japan, namely the Linear Chuo Shinkansen train, this study examines whether the value of transport innovation is capitalized in land prices immediately after the construction plan is announced. We adopt a hedonic approach to measure value, using balanced panel data on residential land prices from 2008 to 2015 in Japan. This study aims to solve estimation problems in the impact evaluation of large-scale transport infrastructure construction projects. We find that residential land prices in the area where the time distance to the Tokyo metropolitan area reduces rose, except in the area where the population is decreasing. This result implies that the benefits are capitalized in land prices when there is demand to shorten the time distance. The estimation results also suggest that the benefits of transport innovation are capitalized in asset prices immediately after the infrastructure construction decision. In addition, we confirm the importance of examining whether "a natural experiment" is an experimental situation.

JEL classification: R4

Keywords: High-speed railway, Residential land price, Inverse probability weighting, Japan

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I. Introduction

High-speed railways benefit society by greatly reducing the time distance between cities and by transporting more people than alternative public transportation modes such as airplane and long-distance bus. The development of high-speed railways promotes industry accumulation in urban areas, develops tourism in rural areas, and, in some cases, changes the residential distribution of people. However, high-speed railways are expensive to build owing to the enormous sunk costs such as the cost of track and expenses for land acquisition. Moreover, the basic plans of high-speed rail construction are often canceled because of budget limitations. Thus, policymakers must be clear that the construction justifies the investment.

This study investigates whether the benefit of high-speed railways is capitalized in residential land prices. We focus on the case of the Linear Chuo Shinkansen train (LCS hereafter) in Japan, which construction of was announced in 2011 and which is scheduled to open in 2027. The aims of this study are to solve estimation problems in the impact evaluation of large-scale transport infrastructure construction projects.[1] While many studies have evaluated the impact of transportation infrastructure development, many suffer from three estimation problems, namely omitted variable bias, location selection bias, and the timing of the treatment. Although there are estimation strategies to address each problem, it is necessary to use a high quality dataset or natural experiment setting to identify the impact. Only a few studies have tackled all three problems when examining the relationship between transport infrastructure and land prices.

[1] Since it is difficult to measure all the benefits of the LCS that have not yet been realized, this study does not estimate its cost-effectiveness.

The definition of the treatment groups is also a major problem when evaluating the impact of large-scale transportation infrastructure. The purpose of high-speed railway construction is to shorten the time distance. Since the effects of reducing the time distance spread throughout the transportation network, it is necessary to define the range of treatment effects carefully.

This study attempts to resolve the above-mentioned estimation and definition problems by using balanced panel data on residential land prices from 2008 to 2015 and information on the time distance to large cities in Japan. The estimation results[2] show that residential land prices in the area where the time distance to the Tokyo metropolitan area reduces rose, except in the area where the population is decreasing. This result implies that the benefits are capitalized in land prices when there is demand to shorten the time distance. The estimation results also suggest that the benefits of transport innovation are capitalized in asset prices immediately after the infrastructure construction decision. In addition, we confirm the importance of examining whether "a natural experiment" is an experimental situation.

The remainder of the paper is organized as follows. Section 2 presents the background of the impact evaluation of transport infrastructure and of the LCS. Section 3 provides an overview of the dataset. Section 4 describes the estimation strategy. Section 5 reports the estimation results. Section 6 concludes.

II. Background

A. Problems of transport infrastructure evaluations

[2] The estimation results report the value including the indirect effects of transport innovation such as expectations of urban development (see Bowes and Ihlanfeldt, 2001).

Many researchers have evaluated the impact of constructing large-scale infrastructure on economic growth and assessed the cost-effectiveness of projects given that most construction costs are sunk cost. However, studies typically suffer from three estimation problems, while the definition of the treatment group is also a challenge in the case of large-scale transportation infrastructure projects.

The first problem in empirical studies is omitted variable bias. Under hedonic approaches, goods are regarded as being composed of a number of attributes and the price of goods is considered to be a bundle of the potential economic value of each attribute. In the case of land prices, land has myriads of unobservable attributes at any time that can even be correlated with each other. Further, the estimators in the hedonic approach are often biased because unobservable attributes are correlated with the treatment variables. For example, it is assumed that land prices around a railway station are higher and thus that the area around a railway station is more developed. However, land prices are affected by both the benefits of the railway links and the benefits associated with the convenience of the developed area. Identifying both benefits is often challenging because it is impossible to observe all the elements of the convenience of the developed area.

Recent research that has examined the relationship between land prices and distance from the train station has considered omitted variable bias. Many studies adopt the fixed effects model to control for the time-invariant and common factors in the neighborhood (e.g. Baum-Snow et al., 2005; Debrezion et al., 2007). The present study also controls for time-invariant factors by adopting an individual fixed effects model and by using balanced individual panel data.

Location selection bias is the second major problem with the impact evaluations of transport infrastructure. One purpose of transport infrastructure construction is to decrease transportation costs for local residents. Hence, transportation infrastructure is usually built in areas where it will be used by more people. Therefore, the observed impact of the infrastructure project includes the effects due to location selection (e.g., future development). Then, changing the outcomes includes the impact of the infrastructure construction and the effect of regional development.

There are two ways in which to overcome location selection bias. The first is by using an experimental approach to exploit a situation that the location choice is treated as-if random. Since the allocation of the treatment is as-if random, the attributes between the treated and untreated groups can be regarded as the same. For example, Billings (2011) measures the value of the light rail constructed in 2000 in Charlotte, North Carolina by adopting a natural experiment. The author defines the relevant control groups (i.e., two lines in the proposed construction plan). If the three areas where construction is planned are similar and one is chosen by chance, we can assume that the attributes of these control areas are similar to those of the construction area.

Several studies that have evaluated the impact of a large transportation infrastructure project have also exploited the natural experimental setting. Banerjee et al. (2012) examine the relationship between access to transportation infrastructure and economic growth in China, exploiting the fact that transportation networks tend to connect historical cities linearly. Although such historical cities that house a terminal could be affected by location selection bias, areas in the geographical middle of these historical cities do not suffer from location selection bias because this is a geographically natural experiment. Therefore, location selection bias can be avoided by evaluating middle areas. In a similar fashion, Datta (2012) investigates the effects of highway improvements on firms in India. As the examined highway was built to connect four metropolitan cities, it can be considered that the intermediate areas through which the highway runs are not selected.[3]

The second approach to addressing location selection bias is by conducting a propensity score matching with difference-in-difference (DID) estimation (called a matching DID, or MDID herein). Propensity score matching aims to control for unobservable attributes to exploit the observable variables. DID measures the average treatment effect by defining a treatment group and a control group, which is similar to the treatment group but is not treated. DID takes the difference of the difference between the before and after treatment on the outcome of each group. If both groups are similar, the difference in outcomes before and after the treatment in both groups is considered to be due to the treatment. Propensity score matching can thus define a control group that resembles the treatment group to alleviate the location selection problem.

In this vein, Gibbons and Machin (2005) investigate whether the reduction in transportation cost by transportation innovation raises land prices in London. They use MDID to consider the location selection bias of transportation innovation as a robustness check. Xu and Nakajima (2015) study the relationship between accessibility to highways and industrial development in China. They use MDID to mitigate the location selection bias of highway construction.

The treatment effect of the intermediate stations of the LCS can be regarded as leading to small location selection bias in the same way as in Banerjee et al. (2012) and Datta (2012). However, as discussed below, the attributes of the treatment and control groups do not necessarily balance even if location selection bias is small. Therefore, in all estimations, this study alleviates selection bias by adopting MDID.

[3] In addition, Michaels (2008) investigates the effect of highway construction by exploiting the natural experimental setting of interstate highways in the United States.

The third problem is the timing of the treatment. When measuring rising property values, it is necessary to consider the timing of the construction decision. Although the transportation services as a flow are provided after opening, the asset price as a stock rises when the service is reliably expected to be operating in the future. Obscuring this timing will underestimate the treatment effect. Several studies have considered this problem (McDonald and Osuji, 1995; McMillen and McDonald, 2004; Billings, 2011). McDonald and Osuji (1995) examine whether railway benefits are capitalized immediately after the construction information is published. The present study assumes that the time of the decision of the construction plan is at the beginning of the treatment similar to McDonald and Osuji (1995). The validity of this assumption is described in Section IIB.

In addition to these three estimation problems, the location of the treated group must be solved. The LCS connects Japan's major cities at the world's highest speed, which creates a large time-shortening effect. This effect is spread widely through the traffic network. If the observational point is added to the control group candidate, although it should be defined as a treatment group, the DID estimator is underestimated. If an excessively broad area is defined as the treatment group, the treatment effect is also underestimated. Hence, to find the observation points where the time distance to metropolitan areas is reduced by using the LCS, we compare the time distance to these areas by using the LCS with that by not using this service.

B. History of the LCS

As noted above, the estimation includes two points; first, the direct benefit of the LCS is a time-shortening effect to large cities such as Tokyo and Nagoya; second, the decision to proceed with the construction plan is the start of the treatment. In this section, we explain the background to the construction of LCS including the opposing opinion on the cost burden of construction, Shinkansen construction announcement, and geographical factors.

The LCS, which is operated by JR Tokai in Japan, is expected start running services between Tokyo and Nagoya in Aichi prefecture in 2027, with services expanded to Osaka from Nagoya station by 2045.[4] Currently, the Tokaido Shinkansen (TS) operated by JR Tokai connects Tokyo station and Osaka station. The TS is the oldest, most famous, and most densely scheduled high-speed railway in Japan. In 2013, 155 million people used the TS. Although the main stations of both Shinkansens (Tokyo, Shinagawa and Nagoya, Osaka) are located at the same station, the intermediate stations of the LCS are built elsewhere (Figure 1).

Insert Figure 1

The construction of the LCS is designed to reduce the time distance between the Tokyo metropolitan area and the Osaka metropolitan area from two and a half hours to just one hour. The LCS is the highest speed railway powered by a linear motor at present in the world.[5] The capacity of each train is about 1000 people, which is approximately twice the size of the largest domestic airplane. Therefore, the reduced time cost of the LCS will create a huge consumer surplus. The other purpose of the construction of the LCS is to provide an alternative route to the TS. The TS, which was opened in 1964, is

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[4] The length of the line between Tokyo station and Nagoya station is 286 km and that between Tokyo station and Osaka station is 438 km.
[5] In 2015, the LCS achieved 603 km per hour in a manned test run, the world's highest speed for land transportation (see http://jr-central.co.jp/news/release/_pdf/000026466.pdf, published in April 21, 2015, in Japanese, last access February 26, 2016).

scheduled a large-scale renovation because and has a shut off risk due to a large earthquake called a Tokai earthquake occurring.[6] Since travelling between Tokyo and Osaka has huge demand, the economic loss of the TS not running is large. Hence, the LCS is a socially desirable alternative mode.

In this regard, however, the construction cost of the LCS is high. The estimated construction cost is about nine trillion yen (¥9×10^{12}), including the cost of rolling stock and excluding interest. In addition, the total construction cost of the four intermediate stations is about 330 billion yen (¥330×10^{9}). Usually in Japan, the government accepts two-thirds of the construction cost of high-speed railways and the local government accepts the rest. However, surprisingly, JR Tokai accepted all the construction costs of the LCS, as the discussion on the cost allocation for each government was prolonged.[7] Then, JR Tokai decided a phased construction plan, constructing the line between Tokyo and Nagoya in the first stage and that between Nagoya and Osaka in the second stage.

To reduce the construction costs of the intermediate stations, the renovation of existing stations and adjustment of connection facilities were postponed until the completion of the line between Tokyo and Osaka in 2045. Furthermore, intermediate stations will have no ticket office and no sales staff in order to reduce operating costs.[8] That is, JR Tokai will build the intermediate stations without considering a transportation network in neighboring regions. A park-and-ride system will be necessary to use the LCS in intermediate stations because access to a nearby railway station will be inconvenient.

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6 In 2011, the Ministry of Education, Culture, Sports, Science and Technology announced that the probability that an eight-magnitude Tokai earthquake would occur in the next 30 years is 87%.

7 Although JR Tokai is a large company whose total assets were 5.2 trillion yen in 2014, accepting the full amount of construction costs alone is still a challenge (see http://jr-central.co.jp/news/release/_pdf/000013337.pdf, published in November 21, 2011, in Japanese, last access February 26, 2016).

8 Trains will adopt a pre-reservation system for all seats.

Next, we describe when the treatment effects of the LCS started. Although the LCS was initially conceived in 1973, it was not until May 2011 when the Ministry of Land, Infrastructure and Transport agreed the construction plan.[9] In August 2011, JR Tokai published the location of the intermediate stations and the rationale for selection in an environmental impact statement at the planning stage,[10] only between Shinagawa station in Tokyo and Nagoya station in Aichi prefecture. It is to be noted that, in Japan, the construction of Shinkansen is not determined. even though basic plan is announced. Shinkansen listed in the basic plan published in 1973 have actually been built only seven of the 17. Further, the date of completion is unknown at the time listed in the basic plan. In other words, the construction of the LCS was determined after the information disclosures in 2011.[11]

Focusing on geographical factors allows us to verify the validity of the natural experiment. The route of the LCS is almost a straight line between Tokyo and Nagoya and is expected to take 40 minutes. The minimum radius of the curvature of this route is 8000 m compared with that of the TS of 2500 m, which is a major restriction on the maximum speed. Because of this problem, the minimum radius of the curvature of the Shinkansens built after TS in Japan is 4000 m.

III. Data

This study uses official land prices, called *Kojichika*, from 2008 to 2015 to

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[9] See "The determination of the construction plan of Chuo Shinakansen" http://www.mlit.go.jp/common/000145486.pdf (published in May 26, 2011, in Japanese, last access last access February 26, 2016).
[10] See "Environmental impact statement at the planning stage of Chuo Shinkansen between Tokyo to Nagoya" http://company.jr-central.co.jp/company/others/assessment/_pdf/04.pdf (published in August, 2011., in Japanese, last access last access February 26, 2016)
[11] Of course, the market may have reacted for some reason before 2011. For information on what to do, this problem is described instead of the identification strategy.

investigate whether the benefits of the LCS are capitalized in residential land prices after 2011. The Land Prices Public Announcement Act (公示地価法) investigates official land prices in Japan. Although official land prices are not actual transaction prices, they are a value evaluated by experts by using actual transaction information taken from the Land Transactions Survey (土地取引状況調査). Therefore, official land prices report a survey price that reflects changes in the market. Further, official land prices have a panel data structure since they are reported on January 1 every year.

These panel data are superior to the panel datasets used by previous studies. First, they are individual panel data. In an analysis of land or asset prices, a researcher typically makes a pooled cross-section data and estimates values by using area fixed effects. However, our panel data can control for the unobservable time-invariant omitted variables by using individual fixed effects. Second, the measurement error is smaller than that in other datasets since experts have evaluated official land prices in order to reduce the information asymmetry in land transactions. For such a reason, information that is not traded is hard to contain.

Observations are selected as places that can build a house under the land use regulations. However, observations are excluded for four prefectures, namely Fukushima, Toyama, Ishikawa, and Okinawa (Figure 2). First, we exclude Fukushima prefecture as it was affected by the Fukushima nuclear accident caused by the Great East Japan Earthquake in 2011. However, because radioactive substances were scattered outside Fukushima, the treatment group belonging to Shinagawa station will include affected points. The distance between Shinagawa station and the Fukushima nuclear power plant is 230 km. As a robustness check, we estimate the average treatment effect on treated (ATT) of the redefined treatment group by distance from Shinagawa station. Second, we exclude Toyama prefecture and Ishikawa prefecture to remove the effect of the Hokuriku Shinkansen that opened in 2015. The Hokuriku Shinkansen connects Tokyo station and Nagano station (Figure 1). It also extends from Nagano station to Toyama prefecture and Ishikawa prefecture. The construction plans of the Hokuriku Shinkansen were published in 2000.[12] The opening of the Hokuriku Shinkansen in 2015 would have increased land prices in Toyama and Ishikawa. Therefore, we exclude those areas from the analysis. Finally, Okinawa is excluded from the analysis. Other small islands also are excluded.

The treatment group is defined as the shortening of the time distance to Tokyo station and Nagoya station. However, five LCS trains an hour travel between Shinagawa station and Nagoya station, four of which do not stop at the intermediate stations. Therefore, we assume that the reduction in the time distance to the intermediate stations is not a benefit. To find the observation point that shortened the time distance to the major city stations, this study uses spatial information about the railway, information about the travel time of all public transportation infrastructures, and spatial information on all road infrastructures.

Evaluating the effects of local railway is straightforward by defining the treatment groups as the distance from the nearest station. However, defining the treatment groups as the distance from the station is unsuitable for evaluating the effects of high-speed railways. We must clarify how the benefits of high-speed railways spread. If we estimate the range of treatment effects too narrowly, the control group candidates include treated observations. This study overcomes this problem of the definition of the treatment group by using a detailed timetable. The Appendix provides details on how the treatment group was defined.

The treatment effect of the LCS can be classified into two types: (i) those that reduce

[12] The basic plan of the Hokuriku Shinkansen was published in 1973.

the time distance to Tokyo and Nagoya (the intermediate stations correspond to this type) and (ii) those that reduce the time distance to Tokyo or Nagoya. The treatment group for which the nearest station is Shinagawa station in Tokyo aims to shorten the time distance to Nagoya station. Conversely, the treatment group for which the nearest station is Nagoya station aims to shorten the time distance to Tokyo station. Focusing on the second type allows us to compare the benefits of the shortening of the time distance to Tokyo station and Nagoya station.

This study adopts a propensity score estimation to control for selection bias. Propensity scores are estimated by using information on the year immediately before the receiving treatment, which is 2011. To estimate a propensity score, information on official land prices in 2011 is combined with the Population Census 2010 and Economic Census for Business Frame 2006.[13] Theses Censuses report an aggregate value for each municipality. By using propensity score matching and the attributes of the neighboring environment, we select a control group that has a land market condition similar to that of the treatment group. In addition, estimating the propensity score uses land price history from 2008 to 2011 in order to select a control group that considers the situation that a market reacts before the treatment such as an Ashenfelter dip (Heckman and Smith, 1999) and the effect of adventitious urban development before the treatment.

Table 1 reports the descriptive statistics. In columns (1) to (6) are the statistics of the treatment group for the LCS stations. Column (7) shows the statistics of the control group candidates. This table shows that the average land price from 2012 to 2015 is lower than that from 2008 to 2011 in Japan. The rate of change of the average land price of Shinagawa station in Tokyo is -10.0%. The land price of the treatment group by

[13] Both Censuses are reported every five years.

intermediate stations in Kanagawa prefecture, Yamanashi prefecture, Nagano prefecture, and Gifu prefecture falls by -6.6, -11.6, -13.1, and -12.2 percentage points, respectively. Moreover, the land price of the treatment group of Nagoya station in Aichi prefecture falls by -8.5 percentage points and that of the control group falls by -9.1 percentage points. According to a simple comparison of these statistics, the declines in the average land prices of the treatment group of the station in Kanagawa prefecture and Nagoya station are smaller than that of the control group.

Table 1 also shows that the opening of the LCS reduces the time distance to Tokyo station of the treatment group except Shinagawa station, and vice versa. There is no clear difference between the control group and treatment groups for distance to the nearest station, acreage, building coverage, and floor area ratio, while the values of population, population trend, and office number and number of employees in the treatment group belonging to the station in Tokyo, Kanagawa, and Nagoya are higher than those in the control group. On the contrary, the population density of the treatment groups of the stations in Yamanashi, Nagano, and Gifu is lower than that of the other groups. Propensity score matching thus mitigates the differences in the covariates between the treatment group and control group.

Insert Talbe 1

IV. Empirical Strategy

This study measures the change in residential land prices before and after the opening of the LCS by adopting a hedonic model. When the time distance to a large city reduces because of transport innovation, the land attributes also change when the market is exposed to such information. For example, land prices will rise because of the discounted present value of the benefit of the transport innovation.

A. Discount rate

In the analysis, we estimate the discounted present value of the LCS. This describes the simplest case of the relationship between the estimation result and the discount rate. We assume that the LCS will open j years after the construction information disclosure. As a result, the change in land prices because of the transport innovation is $\delta LP = LP_j - LP_0$, where LP_j is the land price in the j-th year which is immediately after the opening and and LP_0 is the land price in period 0 which is immediately before the announcement. We also assume that discount rate d is constant over time. Thus, the change in land prices in the first year immediately after the announcement is expressed as $LP_1 - LP_0 = \delta LP / (1+d)^{j-1}$. The interest of this study is the average change rate of land prices from just before the announcement to four years after the announcement.

In our estimation, it is difficult to remove the influence of a specific urban development that is determined after the announcement. The influence of such a specific development may be included in the change in land prices. For example, the decision to stage the Tokyo Olympic Games in 2020 was agreed in September 2013. Our analysis cannot sufficiently remove the influence of infrastructure construction for the Olympic Games on land prices. For this reason, the results must be interpreted carefully.

B. Baseline model

The baseline model measuring the reduction in the time distance to Tokyo and

Nagoya because of the LCS is

$$\ln(LP_{it}) = \alpha + \beta(Treat)_{it} + X'_{it}\gamma + YF_t + FE_i + \varepsilon_{it}, \quad (1)$$

where LP_{it} is the official land price at survey point i in year t, $(Treat)_{it}$ is a dummy indicating whether the survey point belongs to a treatment group in the post-announcement period, X'_{it} represents the control variables of i in t, TF_t is the year fixed effects, and FE_i is the individual fixed effects. That is, $(Treat)_{it}$ is a DID estimator and thus the coefficient β of variable $(Treat)_{it}$ represents the average increasing land price. In other words, β is the discounted present value, which is based on future benefit, immediately after the information disclosure to the land market. YF_t controls for the factors of each year such as the inflation rate. In this study, equation (1) is called a fixed effects DID. For previous impact evaluations of railways, Gibbons and Machin (2005) and Billings (2011) adopt fixed effects DID models by exploiting the quasi-experimental situation.

C. Identification

As described in Section 2, three estimation problems exist when evaluating infrastructure construction in the hedonic model: omitted variable bias, location selection bias, and the timing of the treatment. To control for the time-invariant omitted variables, some studies construct (quasi-) panel data and adopt a fixed effects model (e.g. Gibbons and Machin, 2005). The present study also constructs a balanced panel dataset and adopts individual fixed effects. That is, the first problem is solved substantially in the estimation of equation (1).

Location selection bias is the second problem from which all impact evaluation studies of infrastructure construction suffer. On the one hand, since a railway is built to maximize revenue, the location of the railway station is less likely to be considered to be a natural experiment.[14] The effect of the construction of a terminal LCS station should also be affected by location selection bias. This study mitigates the location selection bias of terminal stations by using propensity score matching.

On the other hand, since the purpose of the LCS is to shorten the time distance between metropolitan areas, the route is straight. Hence, it can be regarded as a natural experiment with respect to the location of intermediate stations. However, the selection bias problem for the treatment effects of such an intermediate station must be noted. In general, if the control group covariates differ from the treatment group covariates, the year trends of the outcome in each group would be different. As a result, the DID estimator is biased. Therefore, balancing the covariates is essential in the DID estimation. However, solving this balancing problem is not easy for the impact evaluation of large-scale transportation infrastructure. The hedonic model obtains an estimate by regressing the price on the characteristics of interest of each good. Hence, the model assumes that demand-side preferences are homogeneous. However, as shown in Table 1, the range affected by the large-scale transportation infrastructure construction might extend beyond a radius of 50 km. In this case, defining a control group for which demand-side preferences can be regarded as equal to those of the treatment group is difficult caused by the spatial sample selection. To address the spatial sample selection problem, control groups for the intermediate stations are also selected by using propensity score matching.

[14] In the case of local railways, the endogeneity of location selection is more serious since engineering constraints such curvature radius and social problems (e.g., the trade-off between train speed and noise) are weaker than for high-speed railways.

The second problems are formulated on the basis of equation (1) as follows:

$$\ln(LP_{it}) = \alpha + (Treat)_{jt}\beta + X'_{it}\gamma + YF_t + FE_i + \eta_{jt} + \varepsilon_{it}, \quad (2)$$

where η_{jt} is the unobservable time-variant factors of group j in t that correlate with $(Treat)_{jt}$. Since the DID estimation assumes that the unobservable time-variant factor in the control and treatment groups is a common trend, the time-variant factors can be controlled for by using year fixed effects, YF_t. However, the η_{jt} of the control and treatment groups is unlikely to be a common trend because the treatment group in terminal stations is biased by location selection and that in intermediate stations is biased by spatial sample selection.

Therefore, we use propensity score matching to define the control group with a similar η_{jt} to the treatment group. This procedure can compare the treated land market to the untreated land market that is similar to the treated market. If both land markets were not treated, land prices would show the same trend. That is, the assumption of a common trend is met in the DID estimation by using propensity score matching.

This study adopts the inverse probability weighting (IPW) technique to eliminate the imbalance between the control group and treatment group covariates using propensity scores as weights. IPW weights $\hat{P}_i / (1 - \hat{P}_i)$, where $\hat{P}_i$ is the propensity score, for the control group to estimate the ATT. As apparent from the equation of weight, this is unsuitable for the estimation when the propensity score is too small or too large. Therefore, observations that have a propensity score of less than 0.1 or more than 0.9 are dropped from the analytical sample.

V. Estimation Results and Discussion

A. ATT for the whole treatment group

Table 2 reports the DID estimations using the whole treatment group. Column (1) shows the result estimated by using OLS. Column (2) shows the result estimated by (1) with individual fixed effects. Column (3) shows the result estimated by (2) with regulated samples that have a propensity score of more than 0.1 and less than 0.9. Column (4) shows the result estimated by (3) with IPW. Since we are using balanced panel data over eight years, the number of observations is eight times the number of individuals.

Although the land prices of the treatment groups belonging to each station tend to decrease in Table 1, every estimator is significantly positive in Table 2. These results imply that the benefits of the LCS are capitalized as the discounted present value immediately after the construction plan is revealed. The difference between columns (1) and (2) is caused by controlling for the time-invariant omitted variables. Furthermore, the difference between columns (2), (3), and (4) is caused by controlling for location selection bias. It can be seen that the estimation result is overestimated by about 2.3 percentage points because of location selection bias. That is, the ATT of the LCS on residential land prices is about 0.5% in the whole treatment group (see Figure 2).

Insert Talbe 2

Insert Figure 2

B. ATT by station

According to Table 1, most of the treatment group belongs to the Shinagawa station area and the Nagoya station area. The ATT of the treatment group in each station could differ because of the difference in the socioeconomic backgrounds of these areas. Table 3 reports the estimation results for each station for the four estimation procedures reported in Table 2. Similar to Table 2, a reliable estimation result is provided by the fixed effects model with IPW in column (4).

Insert Talbe 3

The effect of transport innovation on the residential land prices of the treatment group belonging to Shinagawa station is 3.3 percentage points (see column (2)). However, the rise in land prices is -0.5 percentage points after controlling for location selection bias (column (4)). The benefit of the treatment group belonging to Shinagawa station is reducing the time distance to the Nagoya metropolitan area and further west. This result implies that the benefit does not capitalize in residential land prices, perhaps because Tokyo is overcrowded. The average treatment effect of the treatment group belonging to Nagoya station, the other terminal station, is 1.7 percentage points even after controlling for location selection bias. In other words, the benefit of shortening the time distance to the Tokyo metropolitan area is capitalized in the residential land prices in that area. These results are reasonable because the Tokyo metropolitan area has a population scale about four times that of the Nagoya metropolitan area. That is, the time distance shortening from a smaller economic scale area to a larger economic scale area increases land value in this case.

However, the average treatment effect on the treatment group belonging to each intermediate station is not large. The area showing rising land prices in the estimation results by IPW is only the treatment group belonging to the station in Kanagawa prefecture. Residential land prices in that area have risen by about 1.7 percentage points. On the contrary, residential land prices do not tend to increase around the other stations. Rather, land price decreases are found in the treatment group belonging to the stations in Nagano prefecture and Gifu prefecture. As shown in Table 1, the treatment groups belonging to stations other than the station in Kanagawa have low population density, a higher share of the elderly population, and decreasing population. Although the time distance to a major city has been greatly reduced, those areas could not be selected for residence because of the low utility related to the consumption of goods other than the time distance shortening. This negative estimation result might also have been caused by the treatment groups including areas far from intermediate stations that do not receive the benefits of the LCS. This issue is examined in the following subsections. Nonetheless, the result in Table 3 is consistent with the Fogelian view (Fogel, 1962, 1964) as well as the conclusions of Banerjee et al. (2012) that the construction of transportation infrastructure is worthwhile when in demand.

The result of the intermediate stations allows us to consider the natural experiment for location selection. Therefore, the location selection bias of the intermediate stations is small because of the geographical structure of the LCS. The results for the intermediate stations in column (2) exploit the experimental situation for location selection. However, the result for the station in Kanagawa in column (2) is significantly different from those in columns (3) and (4). This difference appears to be due to sample selection bias based on the spatial concentration of the sample. Further, the estimation results in column (3) are those when using the sample that dropped significantly different residential land markets based on the propensity score. Spatial sample selection bias is mitigated by this procedure. Interestingly, the results in columns (3) and (4) do not differ since the location selection bias of intermediate stations is small because of the geographical experiments.

To confirm the robustness of the analysis using propensity scores in Table 3, we estimate using two types of samples that are limited to the control group candidates. The first sample omits Hokkaido and the second sample omits Kyusyu (see Figure 2). The results are reported in Tables A1 and A2, which confirm no large differences, although the sample size in the control groups in Tables A1 and A2 is less than that in Table 3.

C. Heterogeneity of the ATT in each station

The magnitude of the time distance shortening of the LCS does not vary in the treatment group belonging to terminal stations because, for travel to Tokyo station from Nagoya station, the time distance difference occurs only by using the LCS or the TS. However, as revealed in the estimation results in Table 3, land prices rise in the area that shows demand for time distance shortening. Demand in the area close to the station would be large since it is easy to acquire the benefit. In this section, we examine whether rises in land prices depend on the distance from each station.

Table 4 reports the estimation results using samples redefined depending on the distance from the station adopting IPW. First, we explain the results for the terminal stations. The treatment group belonging to Shinagawa station is widely distributed and the ATT is significantly negative, while the ATT within 20 km of Shinagawa station is not significant. On the contrary, the ATT for over 20 km is significantly negative. The average time distance to Tokyo station for the treatment group within 20 km to 50 km of Shinagawa station is 52.6 minutes (standard deviation is 15 minutes). This time distance is longer than the shortest time distance to Shinagawa station from Nagoya station (40 minutes). Land demand in this area may have moved to the Nagoya area. Moreover, this area includes the city, where land prices decreased because radioactive material was scattered from the Fukushima nuclear power plant (Kawaguchi and Yukutake, 2014). Since the treatment group is close to Fukushima with increasing distance from Shinagawa station, land prices fall.

By contrast, land prices for the treatment group within 100 km of Nagoya station rise, while such land price rises in the treatment group within 20 km are greater. These results imply that the expectation of public urban development and the integration of the private sector as an indirect effect of the LCS are higher in Nagoya station and its periphery. The ATT of the area within 50 km to 100 km is greater than that within 20 km to 50 km since that area includes the city, which would develop further owing to the time distance shortening. The area within 100 km to 200 km includes the Osaka area, but land prices have not yet increased because the extension of the LCS from Nagoya to Osaka is set for 2045.

Next, we explain the results for the intermediate stations. Land prices do not rise significantly in the treatment group over 50 km from the station in Kanagawa prefecture. This finding could explain why only one Shinkansen stops at intermediate stations every hour. Land prices rise in the treatment group within 20 km of the station in Yamanashi prefecture. The station in Yamanashi prefecture is in the center of the Kofu Basin, which has an area of 275 km^2. This result suggests that land prices in this basin rise. The rising land prices in the area within 50 km to 100 km of the station in Yamanashi and within 20 km to 50 km of the station in Nagano prefecture is likely to have occurred because we could not control for the economic development effect of extending the Hokuriku Shinkansen. Moreover, the ATT of Nagano and Gifu is significantly negative in Table 3 because this captures the situation of falling land prices of the treated group far from each station. In sum, the results in Table 4 are consistent with those in Table 3.

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VI. Conclusion

This study investigated whether the benefits of the LCS, a high-speed railway in Japan scheduled to open in 2027, were capitalized in land prices immediately after the announcement of the construction decision. We found that residential land prices in the area that reduced the time distance to the Tokyo metropolitan area rose, except in the area where the population is decreasing. This result implies that benefits are capitalized in land prices when there is demand for time distance shortening.

This study confirmed that the estimation problems that location selection bias and the timing of the treatment must be addressed in impact evaluations. Because the construction of infrastructure is always accompanied by location selection bias, the estimation results in many cases can be overestimated if not carefully controlled for. The findings of this study indicated that sample selection bias may occur when samples are concentrated spatially, even when exploiting an geographical experiment for location selection. Furthermore, the presented findings also indicated the difficulty interpreting the estimation results without considering the starting timing of the treatment. In particular, this problem is serious when the outcome is a stock price and the theoretical background of the analysis is consumer utility maximization. Although infrastructure construction takes a long time, rational consumers take action when construction information is disclosed if its effect is obvious. If the analysis had focused only on the timing after the construction information was disclosed (i.e., a comparative analysis of before and after starting the railway service), it could not have measured the direct effect of the railway.

Two future works are proposed from the findings of this study. The first is to examine changes in the land prices from the disclosure of the construction information to the opening of the LCS. If the time-shortening effect of the LCS is all capitalized immediately after the disclosure, land price changes thereafter would be dependent on the discount rate and additional urban development. The second is to examine how much demand rising land prices need. This is an important issue in determining the burden of construction costs. If there is no demand or demand cannot be created, it would be preferable not to build a station, or the entire infrastructure.

Appendix: Definition of the treatment group

We define the treatment group as the point where the time distance to Tokyo station or Nagoya station by using the LCS is shorter than the current time distance. Therefore, we need information about the time distance to each city station using and not using the LCS, at each survey point.

First, we determine the time distance to the city stations in the case of not using the LCS. Each survey point of the official land price is combined with the spatial information of the nearest railway station. At this time, the time distance from the survey point to the nearest station is defined as the travel time on the shortest time distance route based on the speed limit of the road infrastructure (i.e., the digital roadmap). After this, each survey point is given the time distance to each city station from the nearest station. The information of this time distance is based on YAHOO! JAPAN route information on

October 21, 2011. In the case of changing the nearest train station after October 21, 2011, such as opening or shutting stations, we used information on May 1, 2015.[15] This time distance is the shortest travel time when using all public transportation modes to city stations from each station. This process provides the average waiting time and travel time for each route based on the timetable, and uses the shortest travel time for each transportation mode. Of course, if the survey points of official land prices are far from the metropolis, the transportation mode of airplane is selected. In a word, we define the time distance from the survey points to city stations when not using the LCS as the sum of the shortest travel time from survey points to the nearest station and the shortest travel time from the nearest station to the city station using existing transportation modes.

Next, we describe how to determine the time distance to the city station in the case of using the LCS. Each survey point of the official land prices is combined with the nearest station of the LCS. Here, the method of calculating the time distance to the terminal or intermediate stations is different. First, we describe how to determine the time distance to the terminal stations. For the treatment group belonging to Nagoya station, the time distance is shortened only for Tokyo station. The route from this treatment group to Tokyo station using the LCS is taking the LCS from Nagoya station and transferring to a local train to Shinagawa station. Hence, we define the time distance to Tokyo station of the treatment group belonging to Nagoya station as the sum of the time distance to Tokyo station from Nagoya station using the LCS and the time distance already calculated from the survey points to Nagoya station. Conversely, the treatment group belonging to Shinagawa station is the point where the time distance is shortened to Nagoya station. We define the time distance to Nagoya station as the sum of the time distance to Shinagawa

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[15] We did not have digital information on May 1, 2015.

station via Tokyo station from the survey points because Shinagawa station is close to Tokyo station and the time distance to Nagoya station from Shinagawa station using the LCS. There is a point that the time distance is shorter going directly to Shinagawa station; however, the effect of this measurement error in defining the treatment group is limited.

Second, we describe how to determine the time distance to the intermediate stations. We define the time distance to each city station from the treatment group belonging to an intermediate station as the sum of the time distance to the nearest intermediate station of the LCS from the survey point by car and the time distance to city stations from intermediate stations. The time distance from the survey points to intermediate stations is adopted as the shortest time distance based on the speed limit of each route rather than the shortest route distance, as with the travel time to the nearest station from the survey points.

A timetable for the LCS does not exist. Table A3 reports the average time distances based on the published information. For example, the average time distance from Shinagawa station to Nagoya station is the sum of travel time, 40 minutes, using the LCS and average waiting time, seven minutes. The average time distance to transfer from Shinagawa station to Tokyo station is 16 minutes. The average time distance from the intermediate station to city stations assumes the direct train overtakes the local train. Although this assumption may include a measurement error, the estimation results in Table 4 allow us to check the robustness of these results.

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References

Banerjee, A., Duflo, E., Qian, N., 2012. On the road: Access to transportation infrastructure and economic growth in China, NBER Working Paper 17897.

Baum-Snow, N., Kahn, M.E., Voith, R., 2005. Effects of urban rail transit expansions: Evidence from sixteen cities, 1970-2000, Brookings-Wharton Papers on Urban Affairs, 147–206.

Billings, S.B., 2011. Estimating the value of a new transit option, Regional Science and Urban Economics 41(6), 525–536.

Bowes, D., Ihlanfeldt, K.R., 2001. Identifying the impacts of rail transit stations on residential property values, Journal of Urban Economics 50(1), 1–25.

Datta, S., 2012. The impact of improved highways on Indians firms, Journal of Development Economics 99(1), 46–57.

Debrezion, G., Pels, E., Rietveld, P., 2007. The impact of railway stations on residential and commercial property value: A meta-analysis, Journal of Real Estate Finance and Economics 35(2), 161–180.

Fogel, R., 1962. A quantitative approach to the study of railroads in American economic growth: A report of some preliminary findings, Journal of Economic History 22(2), 163–197.

Fogel, R., 1964. Railroads and American Economic Growth: Essays in Econometric History, Johns Hopkins Press, Baltimore.

Gibbons, S., Machin, S., 2005. Valuing rail access using transport innovations, Journal of Urban Economics 57(1), 148–169.

Heckman, J.J., Smith, J.A., 1999. The pre-programme earnings dip and the determinants of participation in a social programme. Implications for simple programme evaluation strategies, The Economic Journal 109, 313–348.

Kawaguchi, D., Yukutake, N., 2014. Estimating the residential land demand of the Fukushima accident, Discussion Papers 2014-18, Graduate School of Economics, Hitotsubashi University.

McDonald, J.F., Osuji, C.I., 1995. The effect of anticipated transportation improvement on residential land values, Regional Science and Urban Economics 25(3), 261–278.

McMillen, D.P., McDonald, J., 2004. “Reaction of House Price to a New Rapid Transit Line: Chicago’s Midway Line, 1983-1999,” Real Estate Economics 32 (3), 463-486.

Michaels, G., 2008. The effect of trade on the demand for skill: Evidence from the interstate highway system, The Review of Economic and Statistics 90(4), 683–701.

Xu, H., Nakajima, K., 2015. Highways and industrial development in the peripheral regions of China, Papers in Regional Science, DOI: 10.1111/pirs.12198.

Table 1 : Descriptive Statistics

	Treatment Group						
Station / (City)*[1]	Shinagawa	(Hashimoto)	(Kofu)	(Iida)	(Nakatsugawa)	Nagoya	Control group
Prefecture	Tokyo	Kanagawa	Yamanashi	Nagano	Gifu	Aichi	
Land Price (yen/m2)							
Land Price (before)	428780	104433	48116	49783	56110	150651	114637
	(1419431)	(54384)	(29010)	(45182)	(25857)	(361691)	(448476)
Land Price (after)	385811	97537	42541	43255	49242	137822	104163
	(1240708)	(52616)	(25281)	(37511)	(21010)	(297479)	(395143)
Characteristics							
Time distance to Tokyo Station		102	182	242	243	219	216
(minutes)		(31)	(33)	(40)	(45)	(66)	(106)
Time distance to Tokyo Station		92	131	155	180	185	289
using Linear motor car (minutes)		(32)	(48)	(25)	(47)	(67)	(213)
Time distance to Nagoya Station	191	188	251	213	133		244
(minutes)	(64)	(47)	(50)	(35)	(45)		(93)
Time distance to Nagoya Station	155	119	127	117	112		273
using Linear motor car (minutes)	(62)	(32)	(48)	(25)	(47)		(180)
Distance to	1.7	2.7	2.6	1.6	2.8	1.8	2.5
the nearest station (km)	(2.0)	(2.6)	(3.4)	(1.5)	(2.7)	(3.2)	(5.3)
Distance to the nearest	80.5	28.2	65.3	77.2	72.5	147.8	357.4
Linear Station (km)	(109.2)	(34.2)	(77.9)	(34.9)	(51.9)	(104.3)	(332.8)
Acreage	359	443	423	300	296	457	364
	(1599)	(1979)	(693)	(163)	(242)	(3696)	(897)
Building coverage ratio	62	55	62	64	64	63	62
	(12)	(12)	(13)	(10)	(9)	(10)	(12)
Floor-area ratio	237	159	200	221	222	224	212
	(152)	(81)	(95)	(105)	(94)	(119)	(119)
Maching							
Propensity Score*[2]	0.515	0.133	0.118	0.135	0.139	0.473	0.524
	(0.265)	(0.148)	(0.118)	(0.114)	(0.205)	(0.148)	(0.133)
Population	251983	235919	117987	112347	64165	174065	195117
	(204635)	(178032)	(87574)	(93787)	(42810)	(135663)	(150707)
Population density_per_km2	6639	2926	490	257	322	3611	2187
	(5992)	(2327)	(394)	(115)	(912)	(3806)	(2782)
Population ratio of over 65	21.24	20.89	24.76	25.84	28.41	22.82	23.76
	(3.47)	(2.56)	(4.25)	(2.66)	(3.48)	(3.93)	(4.56)
Population trends	2.82	1.36	-1.72	-1.25	-4.00	0.45	-0.42
from 2005 to 2010	(4.79)	(2.40)	(2.82)	(2.34)	(2.46)	(3.94)	(3.95)
office number	11575	12804	6478	5968	3907	8073	8940
	(10058)	(9187)	(5209)	(5413)	(2665)	(6907)	(7326)
number of the employees	145669	143660	59672	55433	31784	86764	93951
	(183551)	(100408)	(49642)	(51378)	(24313)	(83546)	(81372)
Observations	35160	2224	1472	928	272	45920	63832

Notes: standard deviation in parentheses. *1; This line reports the station name. If the station name is undecided, the cell reports the name of the city that the station will be built in. *2; This propensity score is a value calculated using the total sample. It is not a propensity score to be used the analysis in each stations.

Table 2: ATT of transportation innovation on residential land price: estimates on whole sample

	DID		Fixed Effect DID		Fixed Effect DID (0.1<=PS<=0.9)		DID (IPW: 0.1<=PS<=0.9)	
	(1)		(2)		(3)		(4)	
treatD	0.0158	**	0.0284	***	0.0283	***	0.0049	***
	(0.0067)		(0.0011)		(0.0011)		(0.0011)	
Other Controls	✓		✓		✓		✓	
Fixed effect			✓		✓		✓	
Year fixed effect	✓		✓		✓		✓	
Number of obs	149808		149808		144360		144360	
Number of individual			18726		18045		18045	
R-sq (within)	0.656		0.644		0.648		0.623	

Notes: Robust standard error in parentheses. *, **, *** denote significance at the 10, 5 and 1% levels, respectively.

Table 3: ATT of transportation innovation on residential land price by station

	DID		Fixed Effect DID		Fixed Effect DID (0.1<=PS<=0.9)		Fixed Effect DID (IPW: 0.1<=PS<=0.9)	
	(1)		(2)		(3)		(4)	
Tokyo	0.0250	**	0.0326	***	0.0258	***	-0.0055	**
	(0.0099)		(0.0015)		(0.0017)		(0.0020)	
	[83216]		[83216]		[70832]		[70832]	
Kanagawa	0.0188		0.0317	***	0.0178	***	0.0168	***
	(0.0165)		(0.0030)		(0.0051)		(0.0054)	
	[66056]		[66056]		[4320]		[4320]	
Yamanashi	-0.0037		-0.0079	*	0.0127	*	0.0067	
	(0.0262)		(0.0042)		(0.0069)		(0.0071)	
	[65304]		[65304]		[3632]		[3632]	
Nagano	-0.0029		-0.0183	***	-0.0109		-0.0166	**
	(0.0290)		(0.0048)		(0.0085)		(0.0084)	
	[64760]		[64760]		[2176]		[2176]	
Gifu	0.0069		-0.0006		-0.0461		-0.0724	*
	(0.0681)		(0.0130)		(0.0322)		(0.0361)	
	[64104]		[64104]		[176]		[176]	
Nagoya	0.0299	***	0.0445	***	0.0443	***	0.0172	***
	(0.0074)		(0.0014)		(0.0014)		(0.0016)	
	[93976]		[93976]		[91528]		[91528]	

Notes: Robust standard error in parentheses. The Number of observations in square brackets. *, **, *** denote significance at the 10, 5 and 1% levels, respectively.

Table 4: ATT of transportation innovation on residential land price by station & distance

	Tokyo		Kanagawa		Yamanashi		Nagano		Gifu		Nagoya	
DID (IPW: 0.1<=PS<=0.9)												
within 20km	-0.0064		0.0142	***	0.0216	**	0.0207		-		0.0382	***
	(0.0111)		(0.0051)		(0.0100)		(0.0216)		-		(0.0040)	
	[1912]		[2624]		[1648]		[240]		-		[11544]	
20km ~ 50km	-0.0248	***	0.0205	*	0.0385		0.0267	*	-0.0237		0.0209	***
	(0.0022)		(0.0107)		(0.0268)		(0.0147)		(0.0316)		(0.0032)	
	[15384]		[776]		[360]		[136]		[32]		[19304]	
50km ~ 100km	-0.0139	***	-0.02433		0.0423	*	-0.00473		0.01410		0.0336	***
	(0.0028)		(0.0161)		(0.0240)		(0.0113)		(0.0438)		(0.0048)	
	[28712]		[184]		[296]		[1040]		[80]		[11088]	
100km ~ 200km	-0.0234	***	0.01078		-0.0168		-0.0539	***	-0.2004	***	0.0022	
	(0.0067)		(0.0213)		(0.0132)		(0.0138)		(0.0297)		(0.0019)	
	[12928]		[280]		[80]		[96]		[56]		[55968]	

Notes: Robust standard error in parentheses. The Number of observations in square brackets. *, **, *** denote significance at the 10, 5 and 1% levels, respectively.

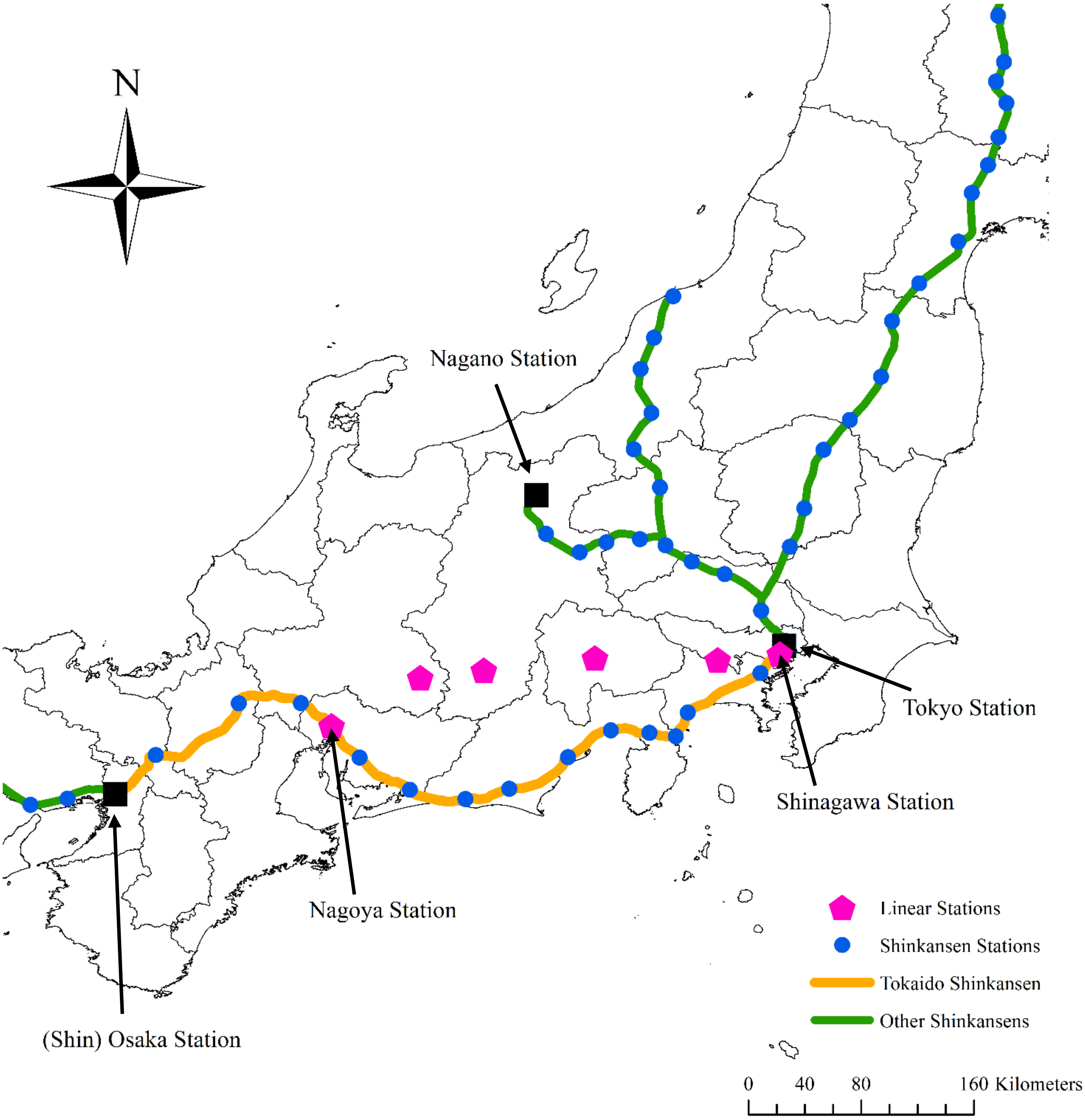

Figure 1: Shinkansen stations in Japan

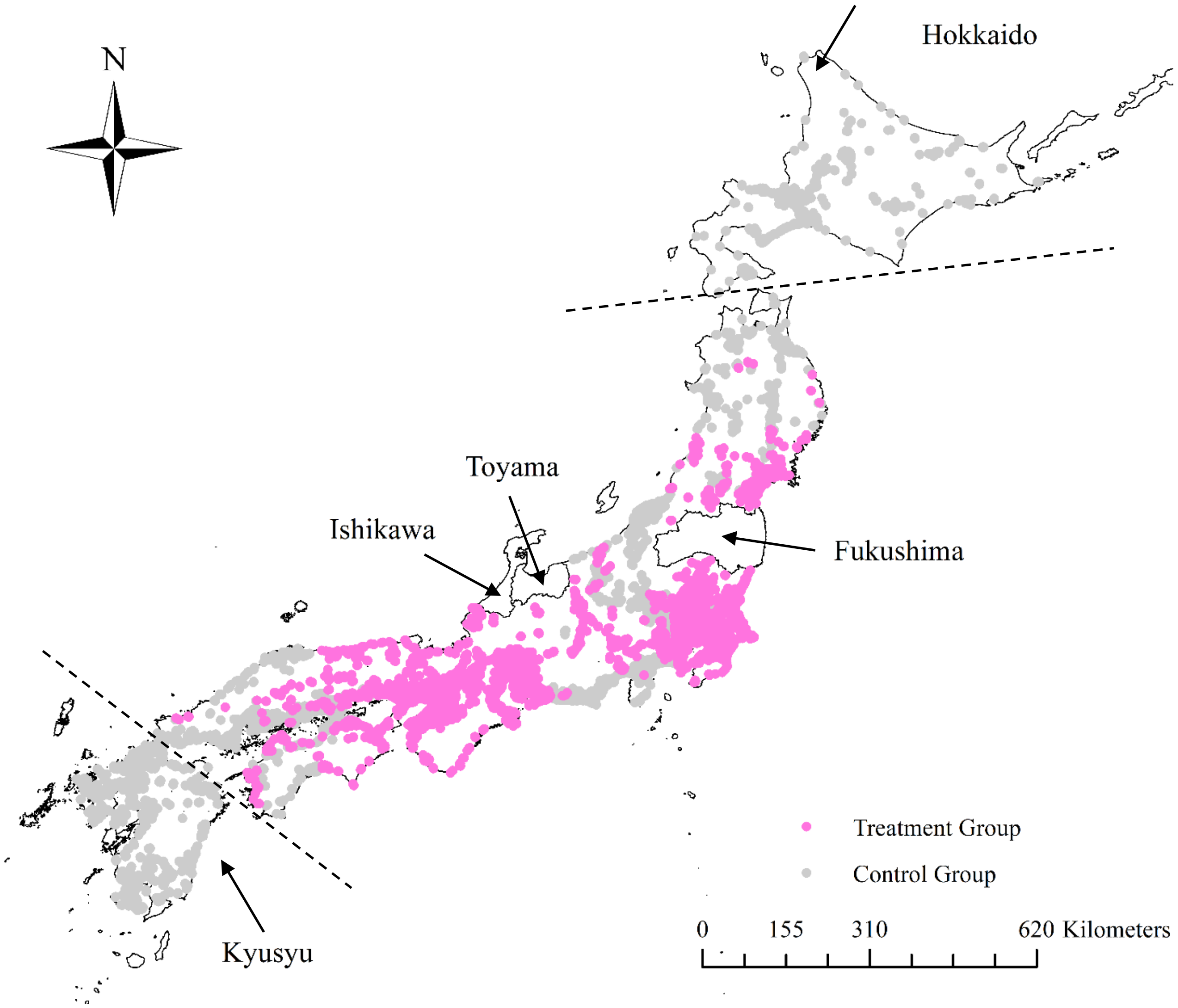

Figure 2: Treatment group and control group

Note: Fukushima prefecture, Toyama prefecture, Ishikawa prefecture, and Okinawa prefecture are dropped in all analyses. Hokkaido prefecture and the Kyusyu area are dropped in the analysis of the robustness checks.

Table A1: ATT of transportation innovation on residential land price by station: estimates except Hokkaido

	DID		Fixed Effect DID		Fixed Effect DID (0.1<=PS<=0.9)		Fixed Effect DID (IPW: 0.1<=PS<=0.9)	
Tokyo	0.0235	**	0.0286	***	0.0224	***	-0.0070	**
	(0.0097)		(0.0015)		(0.0018)		(0.0021)	
	[74168]		[74168]		[61568]		[61568]	
Kanagawa	0.0183		0.0274	***	0.0176	***	0.0176	***
	(0.0158)		(0.0030)		(0.0048)		(0.0060)	
	[57008]		[57008]		[4456]		[4456]	
Yamanashi	-0.0072		-0.0122	***	0.0119	*	0.0082	
	(0.0260)		(0.0042)		(0.0063)		(0.0065)	
	[56256]		[56256]		[4160]		[4160]	
Nagano	-0.0042		-0.0227	***	0.0125	*	0.0020	
	(0.0292)		(0.0048)		(0.0073)		(0.0072)	
	[55712]		[55712]		[2896]		[2896]	
Gifu	0.0053		-0.0051		-0.0508	**	-0.0605	**
	(0.0693)		(0.0130)		(0.0244)		(0.0247)	
	[55056]		[55056]		[280]		[280]	
Nagoya	0.0263	***	0.0406	***	0.0409	***	0.0132	**
	(0.0071)		(0.0015)		(0.0015)		(0.0017)	
	[84928]		[84928]		[82320]		[82320]	

Notes: Robust standard error in parentheses. The Number of observations in square brackets. *, **, *** denote significance at the 10, 5 and 1% levels, respectively.

Table A2: ATT of transportation innovation on residential land price by station: estimates except Kyusyu

	DID		Fixed Effect DID		Fixed Effect DID (0.1<=PS<=0.9)		Fixed Effect DID (IPW: 0.1<=PS<=0.9)	
Tokyo	0.0284	**	0.0363	***	0.0313	***	0.0046	**
	(0.0110)		(0.0017)		(0.0019)		(0.0021)	
	[68848]		[68848]		[57064]		[57064]	
Kanagawa	0.0193		0.0315	***	0.0295	***	0.0212	***
	(0.0172)		(0.0031)		(0.0046)		(0.0047)	
	[51688]		[51688]		[5360]		[5360]	
Yamanashi	-0.0018		-0.0079	*	0.0059		0.0017	
	(0.0268)		(0.0043)		(0.0066)		(0.0069)	
	[50936]		[50936]		[4248]		[4248]	
Nagano	-0.0034		-0.0186	***	-0.0008		-0.0087	
	(0.0302)		(0.0048)		(0.0078)		(0.0081)	
	[50392]		[50392]		[2568]		[2568]	
Gifu	0.0060		-0.0008		-0.0477	*	-0.0651	**
	(0.0698)		(0.0130)		(0.0254)		(0.0313)	
	[49736]		[49736]		[280]		[280]	
Nagoya	0.0326	***	0.0482	***	0.0495	***	0.0263	**
	(0.0088)		(0.0016)		(0.0017)		(0.0017)	
	[79608]		[79608]		[75848]		[75848]	

Notes: Robust standard error in parentheses. The Number of observations in square brackets. *, **, *** denote significance at the 10, 5 and 1% levels, respectively.

Table A3: time distance to metropolirtan Stations by Linear staions (minuts)

	to Tokyo Station	to Nagoya Station
Shinagawa	16	47
(Kanagawa)	57	88
(Yamanashi)	74	74
(Nagano)	91	57
(Gifu)	106	42
Ngoya	63	0

Notes: In parentheses of the intermediate stations, it is entered the name of the city that the station is buil.